isobars, the following approximate errors of the aneroid have been determined for the lowest recorded readings:—

p.m.		Aneroid, inches					inch
7	...	27·300	...	Approximate error			−0·230
8	...	27·200	...	...	...	...	−0·240
8.30	...	27·155	...	...	...	...	—
9	...	27·200	...	...	...	...	−0·230
10	...	27·300	...	...	...	...	−0·220
				Mean error ...		...	−0·230

If the correction + 0·230 inch for instrumental error and height be applied to 27·155 inches, the lowest observed sea-level reading at Kilcreggan was only 27·385 inches—a reading, it may be remarked, agreeing closely with the lowest readings noted at several stations on the mainland and islands of Argyllshire earlier in the evening. The Ochtertyre reading, 27·332, was thus, so far as known, absolutely the lowest recorded during the great storm of January 26, 1884.

THE THEORY OF SUNSPOTS[1]

THE literature of heliography, by no means inconsiderable in extent, has received an addition by the publication of the work before us which, if it makes no attempt to enlarge our knowledge of solar phenomena from personal observation, is deserving of notice as a specimen of one of the modes in which those phenomena are attempted to be explained.

The subject is confessedly full of difficulty as well as interest. Nothing can be more natural than the wish to obtain some knowledge of the constitution of that splendid orb that is the dispenser of life and enjoyment to unnumbered millions of organised beings, and that exhibits on its surface such a strange development of forces commensurate in intensity with its amazing magnitude. But these tempting inquiries are beset with difficulties scarcely to be appreciated in the absence of actual experience. When we bear in mind the amount of light and heat that has to be encountered, with all its consequences in optical, mechanical, and atmospheric impediments, we may rather wonder that man should have been permitted to accomplish so much, than that he should have failed in effecting more. The serviceable working of the telescope soon comes to an end; and what it is able to exhibit it is not able to render intelligible. In strong contrast with the exploration of the selenographer, who feels no doubt as to the general character of his object, whatever perplexities may arise out of the study of its details, the observer of the solar disk knows absolutely nothing as to what he is looking upon. He finds a blazing surface of by no means uniform texture, unlike anything else in the whole compass of his experience. He encounters strange-looking specks that disfigure, if we might venture to use such a word without presumption, the purity and perfection of that brilliant orb. In those dark patches, and their attendant fringe-like borders, what is it that meets the eye? Cavity? or cloud? or eruption? or cyclone? or scoria? Have astronomers succeeded in explaining them? Shall we listen to Wilson, or Herschel, or Kirchhoff, or Nasmyth, or Secchi, or Faye, or Zöllner, or Langley? More or less, they all disagree. Or shall we be venturous enough to attempt an independent solution of the mystery? Little encouragement could be found in such a course. After such protracted discussion we could hardly bring to our telescope an unbiased eye or an impartial judgment. What we are looking for, we should be likely to find. We shall be surrounded with phenomena that lend themselves with perplexing facility to very dissimilar and even opposite interpretations; and, where one observer is confident as to a clear vacancy leading down to unimaginable depths, another fills the same dark area with heavy clouds or floating dross. There may be, and for our own part we believe there are, as in the formerly contested theories of light, details of less equivocal character adequate to guide if not absolutely to establish our judgment; but the ambiguity of the general aspect is sufficiently shown by the support which such conflicting theories have claimed from it, each in its turn.

Perhaps we are disappointed in our telescope. It will be to no purpose to enlarge our aperture or deepen our eyepieces: we are still confronted by an insoluble mystery. We adopt a fresh mode of investigation, the means of which have been but recently placed in our hands; and we bid the spectroscope exert its analysing power and report to us what is there. And now, under the guidance of Lockyer and Janssen and Huggins, we shall be carried a long way in advance, further than the boldest imagination would have dared to anticipate but a few years back; and we find set before us, as in some strange vision, the unmistakable presence of familiar elements, ninety-three millions of miles away. Yet even this triumph of human ingenuity finds there a boundary that it cannot overpass. The evidence, to a great extent conclusive, is sometimes equivocal, sometimes perplexing: affected probably by influences the force and direction of which we can little estimate. The well-known features often wear a strange aspect, and are associated with incomprehensible surroundings. We have succeeded in interrogating the sun: he has answered us, and his answer will surely be reliable:—

"Solem quis dicere falsum
Audeat?"

That is, if we can but comprehend it; but unfortunately the message is not free from obscurity; some of it is in an unknown speech, and "Helium" and "No. 1474" and others of their companions are not only beyond our interpretation, but are likely so to remain. Very wide is the field thus opened for speculation, and very different may be the deductions from the same, or apparently the same, premises, with little possibility of demonstrating that any one combines all the elements of truth. Not one of the current theories has wanted defenders of intelligence and skill; if no one of them clears up all difficulties, no one fails in showing that there is much to be said in its favour; and therefore, as long as no patent absurdity interposes an insuperable bar, we may well exercise toleration to those who do not see through our eyes, or who question to some extent our conclusions. The best result is perhaps not very far in advance of probability, and every claimant has some right to be heard.

Remarks somewhat of this nature may be suggested by the treatise before us, which may be looked upon as an attempt to stem the prevailing current of opinion as to the cause of solar phenomena by showing that they may receive a complete explanation from Zöllner's theory of floating scoriæ, as expanded and developed by the author. The principal results which he has deduced from an extended collation, as it would appear, of the previous observations of others, may be expressed in the following way.—

The sun is to be looked upon as an intensely heated and very gradually cooling ball of monatomic gas, the visible surface of which, or photosphere, is, as Kirchhoff also maintained, composed of iron, with a small admixture of other metals, in a state of glowing fusion, and permeated in every direction by an abundance of incandescent hydrogen, this gas being poured forth abundantly from the exterior of the monatomic nucleus, where the central temperature is sufficiently reduced through decreasing density to admit of the first steps of elemental association. The presence and diffusion of this hydrogen maintains the fused condition of the iron shell, and prevents it from cooling enough to exhibit in every part the

[1] "Die Theorie den Sonnenflecken." Nach den neuesten wissenschaftlichen Forschungen dargestellt von J. E. Broszus. (Berlin, 1884.)

condition which obtains exceptionally in the spots. The "granulated" texture of the photosphere is the result of the eruptive pressure of the internal hydrogen, upheaving and penetrating the glowing mass of iron. The faculæ owe their greater elevation and intensity to an increased activity of the same process; and the chromosphere and the protuberances, whether of the more eruptive or more cloudy character, are traceable to the same origin, the greater brilliancy of the former class being due to the admixture of metallic vapours with the all-pervading hydrogen. The iron shell is not everywhere in a state of equal fluidity, a considerable portion being in a more "pappy" or viscous condition, such as may be seen in our own iron furnaces, which, however, does not render its presence manifest without such a reduction of temperature as to produce opacity. This cooling does not obtain either in the equatorial or polar regions, but is effected in what are known as the "spotted zones," by the overflow of hydrogen from the loftier equatorial strata of the atmosphere. Here, the gas, having been carried up in consequence of the solar rotation into a higher and cooler region, and extending itself laterally as an "equatorial current," descends on the less fluid portions of the photosphere, whence radiation is not so free; they are thus reduced to the more scoriaceous and opaque condition in which they assume the well-known appearance of "spots," while the whirls of cooler vapour on the outside of the main column in its downpour, encountering and tearing away the adjacent metallic edges of the chromosphere, force them to assume the form of those radiated fringes which we know as "penumbræ." The *maxima* and *minima* of the spots, as well as their respective drifting towards the poles or the equator, find their explanation in a "pulsation" or alternate compression and expansion of the globe, chiefly in the direction of its axis, from corresponding alternations in the balance of internal condensation and temperature, each of which is supposed to be in its turn in the ascendant; and though the change of dimension is slight, it is sufficient to give preponderance either to the equatorial or polar current, and, combined with the rotation, to determine the periodicity of the frequency and range of the spots. On the whole, the energy of solar radiation is never compensated; but the waste is so gradual that we have no reason to anticipate any sensible effect for ages to come, and yet so sure that the progressive cooling must terminate in ultimate extinction. In our author's words, "When in some future period of the world the whole of the hydrogen has escaped from the solar nucleus, the sun will cease to shine with its wonted intensity, and will become more and more feeble till at length it hangs in the firmament, a mighty globe of glowing red, as seen from other worlds a ruddy star, which, through rapid cooling, becomes visibly obscured, and, from the formation of everywhere surrounding scoriæ, immersed in deep night,"—a termination of which it may be said that, whatever its intrinsic probability, no reader need look forward to it with the slightest personal apprehension. And were that resplendent body, as Kepler in the exuberance of his imagination believed, the abode of glorious spirits, they might perhaps be supposed to smile at all such anticipations as utterly foreign to the unsearchable designs of the All-wise Creator.

And yet we may not forget that there have been, from time to time, mysterious warnings among the innumerable suns that have their abode in the far depths of space, and we are reminded by no process of argument, but by the evidence of our senses, how untrue it is that "all things continue as they were from the beginning of the creation." The certainty of strange and wonderful catastrophes of outburst or extinction has come to our knowledge, though perhaps only after centuries, or it may have been ages, of the transmission of the recording light: and similar events, to be recognised only by long-distant generations, may be in progress at the present hour. We know very little of the history of the universe, and it becomes us well to speak of such possibilities with caution and reverence. Meanwhile we owe a debt to all who will aid us in the attempt to gratify a very natural curiosity, and to our author among the rest. Some portion of his hypothesis does not come before us for the first time. La Hire in very early days entertained the notion of opaque bodies floating in a fluid mass and occasionally appearing on its surface; and the conclusions of Gautier were very similar as to a partial solidification of metal in fusion; but we must bear in mind that it is only for the diffusion of hydrogen through a liquid envelope of iron that our author claims originality. His ideas are expanded and enforced by so much elaborate reasoning as at any rate to deserve perusal, if they do not succeed in producing conviction. As to this point we may freely confess that the author is more sanguine than ourselves. Some of his arguments are well worthy of attention; but the general character of the treatise is that of an ingenious piece of special pleading, one-sided, but fair and honest in its self-persuasion. A few omissions and mistakes might be pointed out, but they do not impair his argument. The weakness of this, as our readers will have already perceived, lies in the magnitude of some of its assumptions. It might indeed be said that the same objection lies against each of the more commonly received theories; and to this it can only be replied that, though similar in character, it differs in amount; and that the value of any attempt at explanation must be estimated in the inverse ratio of its unproved demands upon our assent.

T. W. WEBB

THE EARTHQUAKE

IN a previous notice (p. 17) brief mention was made of the more obvious conclusions which follow from a consideration of the observed effects of the earthquake of April 22. Mention was also made of some points upon which further knowledge would be of value, notably as to the result of the earthquake upon wells and springs. Mr. De Rance's letters give important information upon this matter.

The measurements of the water in wells at Colchester and Bocking prove that the level of the water has risen seven feet in the former case and from twenty to thirty inches in the latter case. These facts, and also the curious instance of water spouting from the ground at East Mersea, are quite in accord with what frequently occurs during earthquakes. Mr. Mallet says:—"Fissures containing water often spout it up at the moment of shock. Wells, after the shock, alter their water-level, and sometimes the nature of their contents; springs become altered in the volume of water they deliver. . . . It is important to observe whether any changes of level of water in wells take place *prior* to earthquakes. Statements to this effect have frequently been made, but as yet stand much in need of confirmation."

Dr. Taylor's observations that the new and often slightly-built houses have generally suffered less than the old and more solid structures is scarcely what one would have expected. In districts much subject to earthquakes the houses are generally built in such a manner that they yield readily to the vibration, and so mostly escape serious damage. Mr. Mallet indeed believes that if this custom were enforced very little damage would be done. As regards larger and more important structures, the question is not so easily settled; and Messrs. D. and T. Stevenson, in constructing the lighthouses of Japan, employed a peculiar and ingenious contrivance for guarding against the effects of earthquake shocks: this was to interpose a break in the rigid part of the building, and so to prevent the propagation of the shock. Mr. D. Stevenson, in describing this, says:—"The plan I propose for this purpose, which may for brevity be termed an *aseismatic joint*, is